Article

Experimental Support of Spin-mediated Consciousness Theory from Various Sources

Huping Hu* & Maoxin Wu

ABSTRACT

This paper summarizes experimental support to spin-mediated consciousness theory from various sources including the results of our own. In doing so, we also provide explanations based on this theory to experimental phenomena such as out-of-body experience and sensed presence, quantum-like cognitive functions and optical illusions. Whether one agrees or not with the spin-mediated consciousness theory is for one alone to judge. In any event, the importance of the experimental results mentioned in this paper is obvious: quantum effects play important roles in brain/cognitive functions despite of the denials and suspicions of the naysayer and skeptics.

Key Words: spin-mediated consciousness, experimental support.

1. Introduction

The spin-mediated consciousness theory as originally proposed (Hu & Wu, 2002) dealt with the immanent aspect of consciousness such as awareness. Within this framework, the nuclear/electronic spins are the mind-pixels which interact with the brain through quantum effects, modulating and being modulated by various classical brain activities such as the action potentials (Hu & Wu, 2002 & 2004a-d). We have previously discussed how action potentials modulate the dynamics of nuclear/electron spin networks inside the brain through J-coupling, dipolar coupling and chemical shielding tensors, thus, feeding information into mind in the dualistic approach (Hu & Wu, 2004 c & 2004d). Further, based on our own experimental findings and work done by others, we have also discussed on how mind might influence brain through proactive spin processes enabled by the varying high-voltage electric fields inside the brain (Hu & Wu, 2006a-d & 2007a-c). Also, since classical brain activities are largely electric and, in comparison, magnetic field insides the brain is only microscopically strong but fluctuating, we have also considered possible electric spin effect in the brain. This paper summarizes experimental support to spin-mediated consciousness theory from various sources including our own results. In doing so, we also provide explanations based on this theory to experimental phenomena such as out-of-body experience, sensed presence, quantum-like cognitive functions and optical illusions such as Rubin's Vas. For more recent development in

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this theory and a mathematical treatment, please read Hu & Wu, 2009 & 2010 and the Appendix at the end of this paper.

2. The Work of Various Groups in Physics and Chemistry

(a) Spin in quantum computation, quantum memory and quantum entanglement

Theoretically, spin has been shown to be responsible for the quantum effects in both Hestenes (based on Clifford algebra, see, e.g. Hestenes, 1983) and Bohmian (based on quantum potential, see , e.g., Salesi & Recami, 1998) formulations quantum mechanics and more recently in the principle of existence proposed by the herein authors (Hu & Wu, 2009, 2010).

Experimentally, quantum spins of nuclei, electrons and photons have now been successfully manipulated and entangled in various ways for the purposes of quantum computation, memory and communication (e.g., Matsukevich & Kuzmich, 2004; Chanelière, *et al.*, 2005). By way of examples, nuclear spins have relatively long relaxation times after excitations (Gershenfeld & Chuang, 1997). Julsgaard *et al* (2001) achieved long-lived (~.05ms) entanglement of two macroscopic electron spin ensembles in room temperature. Khitrin *et al*, (2002) showed that a nematic liquid crystal is irradiated with multi-frequency pulse magnetic fields, its ^{1}H spins can form long-lived intra-molecular quantum coherence with entanglement for information storage.

The above facts suggest that the quantum entities inside the brains responsible for brain functions such as awareness are likely nuclear and/or electronic spins. Indeed, neural membranes and proteins contain vast numbers of nuclear spins such as ^{1}H, ^{13}C, ^{31}P and ^{15}N. These nuclear spins and unpaired electronic spins are the natural targets of interaction with action potentials in the brain through their motions and the photons of the magnetic pulses or other sources. These spins form complex intra- and inter-molecular networks through various intra-molecular J- and dipolar couplings and both short- and long-range intermolecular dipolar couplings.

(b) Electric spin effects in spintronics

Recent studies in spintronics have shown that an electric field will exert a transverse torque/force on a moving spin (see, *e.g.*, Sun *et al* 2004; Shen, 2005). This is actually not hard to understand since according to special theory of relativity a moving spin in an electric field sees a magnetic field. Sun *et al* (2004) has shown that a moving spin is affected by an external electric field and feels a force/torque as $\mathbf{m}\times[(\mathbf{v}/c^2)\times\mathbf{E}]$ where **m** and **v** are respectively the magnetic moment and the velocity of the moving spin and **E** is the external magnetic field. Shen (2005) has shown that, as a relativistic quantum mechanical effect, an external electric field exerts a transverse force on an electron spin 1/2 if the electron is moving. The said spin force, analogue to the Lorentz force on an electron charge in a magnetic field, is perpendicular to the electric field and the spin motion when the spin polarization is projected along the electric field (*Id*).

Indeed, this effect has just been successfully used in the laboratory to flip the spin of an electron in a quantum dot by applying an oscillating electric field (Nowack, *et al*, 2007). The electric field induces coherent transitions (Rabi oscillations) between spin-up and spin-down with 90°

rotations as fast as ~55 ns and the analysis done by the authors indicates that the electrically-induced spin transitions are mediated by the spin-orbit interaction (*Id*).

Therefore, the interactions between the moving nuclear/electronic spins in neural membranes and proteins and the varying high-voltage electric fields there directly feed information into mind in the dualistic mind-brain approach of spin mediated consciousness theory. To illustrate this particular mechanism, we now consider the spin transverse force exerted on a proton spin of a hydrogen atom connected to the carbon chain of a phosphate lipid located inside the neural membranes as shown in Figure 1. As the carbon chain rotates in parallel to the intense electric field **E** across the neural membranes, the vertical proton spin moving in a circle perpendicular to the carbon chain sees a magnetic field in the rotating frame of reference thus feels a transverse torque/force ***f*** toward the rotating plane. Quantitative calculations shall be performed in a separate paper.

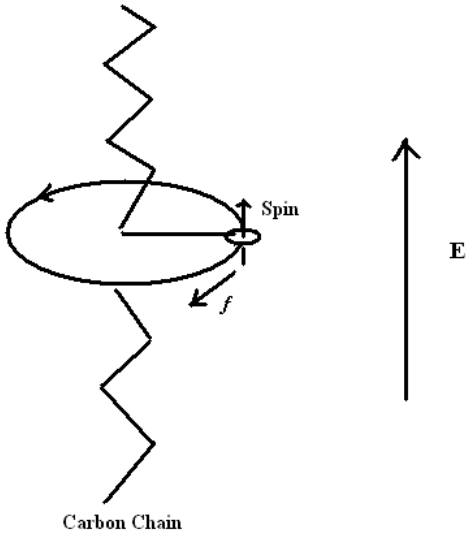

Fig.1. Illustration of spin transverse torque/force ***f*** exerted on a nuclear/electronic spin on a molecular chain or fragment inside the neural membranes and proteins.

This spin transverse torque/force enables the neural spike trains to directly influence the nuclear/electronic spin networks in neural membranes and proteins thus inputting information into mind in the dualistic approach.

(c) Dirac-Hestenes Electric Dipole

It has been long known that in an external electric field, the Dirac particle such as an electron or nuclear sub-entity acts as if it has an imaginary electric moment $i|\mathbf{d}|=ie\hbar/2mc$ (Dirac, 1928). It was Hestenes who showed that Dirac magnetic and electric dipole moments have same origin associated with spin and magnetization (For a review, see, Hestenes, 2003). In Hestenes' formulism, magnetic moment density is not directly proportional to the spin but "dually proportional." The duality factor $e^{i\beta}$ has the effect of generating an effective electric dipole

moment for the Dirac particle. Hestenes commented that "this seems to conflict with experimental evidence that the electron has no detectable electric moment, but the issue is subtle" (*Id*). Hestenes recently released two papers addressing this very same issue (Hestenes, 2008a & 2008b). He now proposes a zitterbewegung model which can either be regarded as a quasi-classical approximation that embodies structural features of the Dirac equation or treated as a formulation of fundamental properties of the electron that are manifested in the Dirac equation in some kind of average form. His suggested averaging over zitterbewegung as seen in the rest frame of the Dirac particle contains both a real magnetic dipole and real electric dipole (*id*). Hestenes further believes that this real electric dipole might already have experimental support (*id*).

Other researchers have also shown recently that the magnetic and electric dipole moments of a fermion are closely related because they determine the real and imaginary part of the same physical quantity (Feng *et al*, 2001; Graesser & Thomas, 2002). Further, Silenko has recently shown in the Foldy-Wouthuysen representation that although the influence of the electric dipole moment on the Dirac particle motion is negligibly small in an external electric field, it influences significantly the spin motion of the said particle (Silenko, 2006).

Furthermore, in the classical models of the Dirac particle, fast oscillating electric dipole moments also appear (Rivas, 2005; Gauthier 2006). These findings coincide with earlier finding that a moving magnetic dipole induces an electric dipole $\mathbf{d}=(\mathbf{v}/c^2)\times\mathbf{m}$, where **m** and **v** are respectively the magnetic moment and the velocity of the moving spin, as a relativistic effect (Rosser, 1964). Rivas (2005) believes that what is lacking in the typical quantum mechanical wave equation is this oscillating electric dipole. He states that "in general, the average value of this term in an electric field of smooth variation is zero, [but] in high intensity fields or in intergranular areas in which the effective potentials are low, but their gradients could be very high, this average value should not be negligible." Rivas further showed that the electric moment of the classical Dirac electron could lead to interesting physical effects (*Id*).

In the context of spin-mediated consciousness theory the interactions between the Dirac-Hestenes electric dipoles of nuclei and/or electrons with the varying high-voltage electric fields inside the neural membranes and proteins may directly feed information carried by the neural spike trains into mind through the varying high-voltage action potentials. Even if the Dirac electric dipole is purely imaginary with no known physical consequence, we argue that in the dualistic mind-brain approach, it may serve as an information receiver in the non-local domain where mind resides for the simple reason that such non-local domain is likely amicable to a description by the imaginary numbers (See, e.g., Rauscher & Targ, 2001). Secondly, we have shown that electric dipole is intrinsically associated with a Dirac particle actually being a composite entity with the unmanifested negative energy side of the entity inseparably accompanying positive energy side of the entity. The unmanifested side of the entity is an active participant in the primordial self-referential spin processes driving quantum mechanics, spacetime dynamics and consciousness (See, Hu & Wu, 2003, 2004b, 2009 & 2010).

3. The Work of Michael Persinger's Group

(a) Sensed Presence & Out-of-Body Experience

Persinger (1993, 2010a) is a pioneer in this field and have done ground-breaking experimental work over the years. In a recent article he and his colleague(s) summarize their results as follows (Michael, 2010a):

> Quantitative EEG data indicate that a sequence of stimulation by between 1 and 5 uT fields at the scalp's surface with as little as 10% greater intensity over the right hemisphere compared to the left is associated with greater convergence of theta activity between the left temporal and right prefrontal region. Subsequent bilateral stimulation is associated with greater right-to-left temporal coherence. These two experimental conditions and quantitative EEG patterns are associated with reports of out-of-body experiences and the sensed presence, respectively.
> …
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> The results and approaches of our research and those of Olaf Blanke both show that out-of-body-experiences and the sensed presence can be generated experimentally by stimulating either one or the other of the hemispheres within specific regions. The quality of the experiences, although direct comparisons have not been made, appears to be similar and the quantitative or meaningful intensity reveal similar values for individual salience.
> …
>
> [We] reviewed and re-analyzed the approximately 20 experiments involving 407 subjects that have demonstrated the experimental elicitation of either the sensed presence or out of body experience. [Our] re-analyses clearly showed the specific magnetic configurations and not the subjects' exotic beliefs or suggestibility was responsible for the increased incidence of sensed presences. The subjects' histories of spontaneous sensed presences before the experiment (and exposure to the magnetic fields) were moderately correlated with exotic beliefs and temporal lobe sensitivity. The side attributed to the presence at the time of the experience was affected by the parameters of the fields, the hemisphere to which they were maximized, and the person's *a priori* beliefs.

In vivid terms one test subject in Persinger's experiment reported "I felt a presence behind me and then along the left side. When I tried to focus on the position, the presence moved. Every time I tried to sense where it was, it moved around. When it moved to the right side, I experienced a deep sense of security like I have not experienced before. I started to cry when I felt it slowly fade away ([Persinger] had changed the field patterns)".

Also in vivid terms, another test subject reported an out-of-body experience stating "I feel as if there was a bright white light in front of me. I saw a black spot that became a funnel....no tunnel that I felt drawn into. I felt moving, like spinning forward through it. I began to feel the presence of people, but I could not see them. They were along my sides. They were colourless and grey looking. I know I was in the chamber but it was very real. I suddenly felt intense fear and felt ice cold."

Persinger and colleague (2010a) reasoned that:

> Our primary assumption is that consciousness and its variants of mystical states can be expressed as quantum phenomena. If consciousness and thought are coupled to electron movements, then a macroscopic manifestation should be congruent with the magnetic field strengths associated with neurocognitive activities. Access to the information within the movements of an electron, its fundamental charge, and the photon emissions associated with changes in electron movements, would allow mystical states and the information with which they are associated to have alternative interpretations that recruit the fundamental properties of space-time and matter.

Persinger et. al.'s above experimental results provide strong experimental proof of the spin-mediated consciousness theory for the reasons stated below:

First, the primary targets of interactions for the weak pulsed magnetic field used by Persinger's Group are the nuclear and/or electron spins associated with the neural membranes, protein and water etc. Indeed, neural membranes and proteins contain vast numbers of nuclear spins such as ^{1}H, ^{13}C, ^{31}P and ^{15}N.

Second, as we have experimentally demonstrated (Hu & Wu, 2006a-c), pulsed electromagnetic fields (photons) carries information through quantum entanglement from external substance (and environment) which they interacted with.

Third, nuclear spins in the brain form complex intra- and inter-molecular networks through various intra-molecular J- and dipolar couplings and both short- and long-range intermolecular dipolar couplings. Further, nuclear spins have relatively long relaxation times after excitations (Gershenfeld & Chuang, 1997).

Fourth, quantum spin is a fundamental quantum process with intrinsic connection to the structure of space-time (Dirac, 1928) and was shown to be responsible for the quantum effects in both Hestenes and Bohmian quantum mechanics (Hestenes, 1983; Salesi & Recami, 1998).

Therefore, altered states of consciousness such as sensed presence and out-of-body experience whether they are produced by magnetic, electric or other stimulations or circumstances can be most effectively explained as the changes of the relative contents and/or intensities of the test subjects' neural quantum entanglement with their surroundings etc. (including possibly spiritual environments/information!).

(b) Apparent Non-local EEG Correlations under Weak Pulsed Magnetic Field

In 2003, Persinger's group demonstrated that the power within a specific band of theta activity in one person was enhanced while another receives circumcerebral pulsed magnetic field involving siblings which they suggested as a possible mechanism for cognitive influence at a distance (Persinger et al, 2003, also see Persinger & Lavallee, 2010b for a summary of this and their later work):

> In the experiment with siblings, one wore the eight-solenoid device while sitting in a closed acoustic chamber (which was also a Faraday Cage) while the other sibling's EEG was recorded from eight locations over the left and right frontal, temporal, parietal, and occipital lobes. The latter sibling or response person sat blindfolded in the dark in other rooms either 5 m or 10 m away. A 20 sec baseline of the quantitative EEG (QEEG) activity was recorded and stored. During each of the 6 different serially presented 5 min configurations of rotating (circumcerebral) magnetic field presentations to the "stimulus" person in the chamber 20 sec of QEEG measurements were recorded for the response person. During the recording period the stimulus person in the chamber was asked to imagine being in the other room with their sibling and touching him or her.
>
> The results were clear. When the 20+2 ms presentations occurred the response person's EEG showed increased power within the theta range, particularly 5 Hz to 5.9 Hz but only if the stimulus person was imagining being near the response person. The greatest increase occurred over the (right) parietal lobe. Many of the response persons reported a sensed presence along their left sides at this time as well. The effect did not occur when there was no magnetic field being generated around the head of the stimulus person and much less so during other configurations.

More experiments were designed and carried out more recently (see, Persinger & Lavallee, 2010b):

> 8 students (for four pairs) were randomly selected from the class roster of about 80 students …Each pair was instructed to meet twice per week for one hour for four consecutive weeks…to establish a history of proximity without either genetic or familial factors… On the day of the experiment pairs were exposed to the same procedures as those subjects in the sibling study. When the stimulus person in the chamber was wearing the equipment that generated the circumcerebral magnetic fields with 20+2 configurations and imagining being in the room with the response person, his or her EEG displayed increased power within the theta range….When the stimulus person during the 20+2 field presentations was simply thinking about the other (response) person, he or she showed a marked increase in the feeling of a sensed presence, anger, and sexual arousal. Such experiences did not occur for the stimulus persons. Pairs of random strangers, obtained by recruiting people walking by the laboratory and who were exposed to the same procedures did not display significant changes in either their EEG profile or their subjective experiences.

In a third variation, Persinger's group (see, Persinger & Lavallee, 2010b) tested the concept of macroscopic entanglement by simultaneously measuring the quantitative EEG of pairs of people

separated by about 75 m:

> They found that about 50% of the variance of the simultaneous EEG power was shared between the pairs of brains. Considering the measurements by Mulligan et al (2010) that showed significant correlations between power within the theta and gamma bands over the right prefrontal regions and daily geomagnetic activity, such "excessive" correlations would be expected. Both members of the pairs would have been exposed to similar geomagnetic activity. This third factor would have produced the apparent coherence or "excess correlations".
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> The critical observation for this study was the direction of the correlations. Pairs of strangers showed positive correlations in power output within the alpha and gamma bands over the frontal and temporal lobes. This would be expected if a third recondite (to the observers) factor produced both. However, people who shared a reinforcement history (that previously shared locations) displayed *negative* correlations in power within the alpha and theta band over these regions. This could be considered an analogue of quantum phenomena when the state of one particle is opposite to the one with which it is entangled. Direct measurements with a fluxgate magnetometer of the static geomagnetic field intensities within both locations where the EEG measurements were taken were unusually similar, as if they were "the same" space.

Another variation was also carried out by Persinger's group (see, Persinger & Lavallee, 2010b):

> To create spatial identities we employed two, eight circular solenoid systems separated by 15 m. One person sat within the acoustic chamber and wore one unit while a second person sat blind-folded in the dark in a separate room wearing the second unit. The two units were synchronized by being connected to the same computer that generated the complex, altering-velocity rotating magnetic fields to both brains simultaneously....While both the stimulus person and the response person were exposed to the same complex configurational magnetic field the stimulus person was exposed to flashes of white light of about 1 lux for 30 s intervals. The flash frequency was between 4 and 15 Hz. At the same time the QEEG for the response person was measured for 20 s just before and 20 s during the light flashes were presented to the stimulus person. In several experiments involving three different sets of experimenters employing the same paradigm, the response subjects' power profiles from QEEG analyses showed increases within the right parietal-temporal region only when the stimulus person was watching the light flashes.

In yet another experiment, Persinger's group (see, Persinger & Lavallee, 2010b) "measured the energy of photon emissions from the response person while the stimulus person was exposed to the flashing lights:

> In this situation the stimulus person sat within the closed acoustic chamber while the response person sat blindfolded 10 m away in a closed, dark room. Instead of measuring

> EEG activity, a photomultiplier tube (PMT) was placed 15 cm away form the right hemisphere on the same plane as the temporal lobe….The measurements were also consistent with the hypothesis by Bokkon (2005) and his colleagues that biophotons are not only routinely emitted from neuronal processes such as action potentials, but may be an energetic field that actually is the visual experience associated with visual perception and dreaming.
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> …
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> Analyses of the data indicated that when the stimulus person was watching the diffuse light flashes there was a net increase of about 10^{-11} W/m^2 from the response person's right hemisphere….Three pairs of stimulus-response persons were tested and all three response persons displayed this effect. One of them reported perceiving "white light" in the visual field, even though the subject was sitting in the dark and blind folded, during 5 of the 6 intervals the stimulus person was watching the light flash. Obviously, the person was not told when the light would be presented to the stimulus person.

Persinger (see, Persinger & Lavallee, 2010b) reasoned that "although interesting the apparent support for macroentanglement did not meet the qualitative criteria or the essential procedural operations of what Bohr and Schrödinger had envisioned. Entanglement involves a process by which two particles (or by inference an aggregate of particles that behave as a single particle) respond simultaneously to a change in each others states despite the distance between them at anytime after their diminished close proximity. In other words the two distal particles are still responding as if they occupy the same space or may even be the same particle with the potential for two different states."

Again, Persinger et. al.'s above experimental results provide strong experimental proof of the spin-mediated consciousness theory for the reasons stated above and somewhat repeated below:

First, the primary targets of interactions for the weak pulsed magnetic field used by Persinger's Group are the nuclear and/or electron spins associated with the neural membranes, protein and water etc. Indeed, neural membranes and proteins contain vast numbers of nuclear spins such as ^{1}H, ^{13}C, ^{31}P and ^{15}N.

Second, we have experimentally demonstrated (Hu & Wu, 2006d, 2007a) non-local physical, chemical and gravitational effects in a first physical system (water) when a second one (water) quantum-entangled with the first one was manipulated.

Therefore, the apparent non-local EEG correlations obtained by Persinger's group with weak pulsed magnetic field can be most effectively explained as caused by non-local effect through quantum entanglement mediated by nuclear/electron spins in the brain.

4. The Work of Elio Conte & His Colleagues

In 2003, Conte et. al. found preliminary evidence of quantum-like behavior in measurements of mental states which were represented by Hilbert space vectors. For comparison, see Aerts, et al. (2000). According to Conte (2003):

> Such a representation induces huge reduction of information about a mental state....Our quantum-like approach describes statistics of measurements of cognitive systems with the aim to ascertain if cognitive systems behave as quantum-like systems where here quantum-like cognitive behavior means that cognitive systems result to be very sensitive to changes of the context with regard to the complex of the mental conditions.

In 2009, Conte et. al. Also found that mental states follow quantum mechanics during perception and cognition of ambiguous figures. For comparison, see Manousakis (2007). Again, according to Conte et.al. (2009):

> Processes undergoing quantum mechanics, exhibit quantum interference effects. In this case quantum probabilities result to be different from classical probabilities because they contain an additional main point that in fact is called the quantum interference term. We use ambiguous figures to analyse if during perception cognition of human subjects we have violation of the classical probability field and quantum interference. The experiments, conducted on a group of 256 subjects, evidence that we have such quantum effect. Therefore, mental states, during perception cognition of ambiguous figures, follow quantum mechanics.

In 2010, Conte has presented a new synthesis of quantum-like cognitive functions based on his theoretical work on Clifford algebra formulation of quantum mechanics and experimental work on quantum-like entanglement and interference in human cognition (Conte et. al., 2010). Conte has detailed and elaborated on how "we think in a quantum probabilistic manner." Here he has first reformulated Aerts' work on possible violations of Bell's inequality in concept combinations. Then Conte discussed and formulated with Clifford algebra the notion and properties of self in line with Jung's work on the subject. Conte and his colleagues have designed and carried out important experiments in an attempt to verify if Jung's theory has a possible quantum formulation (Conte et. al., 2010). Remarkably, their results seem to confirm this. As Conte put it, "[i]n particular, psychological functions and attitudes seem to realize in a large percentage of cases quantum entanglement." Through out the text, Conte lists five pieces of evidence including several experiments did by him and his colleagues to show that quantum mechanics is directly involved in the dynamics of the mental states.

With respect to spin-mediated consciousness theory, although the elements in Conte's Clifford algebra formulation are abstract entities which are fundamentally important in his work, these elements are usually expressed as Pauli matrices associated with spin in standard quantum mechanics. Thus, since matter is, according to Conte, interfaced with cognitive feature, it is possible that this interface is accomplished by the important role of spin at the neuro-physiological level. Therefore, Conte et. al.'s important experiments demonstrating

quantum-like behavoris in human cognition have natural explanations based the spin-mediated consciousness theory at the neuro-physiological level.

5. Optical Illusions

The optical illusion occurs when a person is viewing an ambigous figure such as the Rubin's vase (see Figure 2). At any one instant the figure can be perceived in one way or the other but not both, that is, what is perceived flips between two things. Manousakis (2007) recently suggested that conscious awareness of the ambigous figure could be based on certain quantum effect in the brain.

Figure 2 (Source: Wikipedia)

Manousakis (2007) theorized that conscious awareness is generated anew each time the person flips an ambiguous figure which is represented in the brain as a quantum superposition of two distinctive quantum states by collapsing the superpositioned state into one thing or the other.

Manousakis (2007) conducted experiments in which test subjects had their brain activity measured with EEG and MRI imaging while looking at ambiguous figures. He then calculated the firing rates of neurons before, during, and after the test subjects flipped the images the patterns of which he claimed to be characteristic of the quantum effects that underly conscious awareness. Many researchers dispute Manousakis' claims and offer alternative classical interpretations.

We agree with Manousakis that the flipping of ambiguous figure by the test subject is a quantum effect. Indeed, the work of Conte et. al. (2009) discussed above also support this suggestion.

With respect to spin-mediated consciousness theory, it provides the simplest, most natural and most plausible base in that the macroscopic quantum superposition in the brain is formed by the collective spin state of nuclear and/or electron spins in the brain.

6. Our Own Experimental Work

(a) Non-local Effects in the Brain Caused by External Chemical Substances

It is commonly believed that quantum entanglement alone cannot be used to transmit classical information, although quantum entanglement is ubiquitous in the microscopic world and manifests itself macroscopically under some circumstances (Julsgaard *et al.*, 2001 & 2004; Ghosh *et al.*, 2003). In order to test the spin mediated consciousness theory we just went ahead with experiments instead of armchair debate by first attempting to entangle the electronic/nuclear spins inside the brain with those of a chemical substance such as a general anesthetic and then observing the resulting brain effects such attempt may produce, if any (Hu & Wu, 2006b & 2006c).

Here we summarize our experimental results. We found that applying magnetic pulses to the brain when a general anesthetic sample was placed in between caused the brain to feel the effect of said anesthetic for several hours after the treatment as if the test subject had actually inhaled the same (Hu & Wu, 2006b & 2006c). We then verified that the said brain effect is indeed the consequence of quantum entanglement between quantum entities inside the brain and those of the chemical substance under study induced by the photons of the magnetic pulses or applied lights (id). We suggest that the said quantum entities inside the brain are nuclear or electronic spins (id).

A typical setup for one set of experiments was comprised of a magnetic coil with an estimated 20W output placed at one inch above the right side of a test subject's forehead, a small flat glass-container inserted between the magnetic coil and the forehead, and an audio system with adjustable power output and frequency spectrum controls connected to the magnetic coil. When music is played on the audio system, the said magnetic coil produces magnetic pulses with frequencies in the range of 5Hz to10kHz. Experiments were conducted with said container being filled with different general anesthetics, medications, or nothing/water as control, and the test subject being exposed to the magnetic pulses for 10min and not being told the content in the container or details of the experiments. The indicators used to measure the brain effect of said treatment were the first-person experiences of any unusual sensations such as numbness, drowsiness and/or euphoria which the subject felt after the treatment and the relative degrees of these unusual sensations on a scale of 10 with 0=nothing, 1=weak, 2=light moderate, 3=moderate, 4=light strong, 5=strong, 6=heavily strong, 7=very strong, 8=intensely strong, 9=extremely strong and 10=intolerable. The durations of the unusual sensations and other symptoms after the treatment such as nausea or headache were also recorded.

A typical setup for a second set of experiments was comprised of the magnetic coil connected to the audio system, a large flat glass-container filled with 200ml fresh tap water and the small flat glass-container inserted between the magnetic coil and larger glass-container. Figure 3 shows a typical setup for the second set of experiments when a red laser with a 50mW output and wavelengths of 635nm – 675nm was used. All Experiments were conducted in the dark with the

small flat glass-container being filled with different general anesthetics, medications, or nothing/water as control, the large glass-container being filled with 200ml fresh tap water and exposed to the magnetic pulses or laser light for 30min and the test subject consuming the treated tap water but not being told the content in the small container or details of the experiments. The indicators used for measuring the brain effects were the same as those used in the first set of experiments. Experiments were also carried out respectively with a 1200W microwave oven and a flashlight powered by two size-D batteries. When the microwave oven was used, a glass tube containing 20ml fresh tap water was submerged into a larger glass tube containing 50ml general anesthetic and exposed to microwave radiation for 5sec. The said procedure was repeated for multiple times to collect a total of 200ml treated tap water for consumption. When the flashlight was used, the magnetic coil shown in Figure 2 was replaced with the flashlight.

To verify that the brain effects experienced by the test subjects were the consequences of quantum entanglement between quantum entities inside the brain and those in the chemical substances under study, the following additional experiments were carried out:

In the first set of entanglement verification experiments, the laser light from the red laser first passed through the large glass-container with 200ml fresh tap water and then through the small flat glass-container filled with a chemical substance or nothing/water as control located about 300cm away. After 30min of exposure to the laser light, a test subject consumed the exposed tap water without being told the content in the small container or details of the experiments and reported the brain effects felt for the next several hours.

In the second set of entanglement verification experiments, 400ml fresh tap water in a glass-container was first exposed to the radiation of the magnetic coil for 30min or that of the 1500W microwave oven for 2min. Then the test subject immediately consumed one-half of the water so exposed. After 30min from the time of consumption the other half was exposed to magnetic pulses or laser light for 30 minutes using the setup shown in Figure 2 and Figure 4 respectively. The test subject reported, without being told the content in the small container or details of the experiments, the brain effects felt for the whole period from the time of consumption to several hours after the exposure had stopped.

In the third set of entanglement verification experiments, one-half of 400ml Poland Spring water with a shelve time of at least three months was immediately consumed by the test subject. After 30min from the time of consumption the other half was exposed to the magnetic pulses or laser light for 30min using the setup shown in Figure 2 and Figure 4 respectively. Test subject reported, without being told the content in the small container or details of the experiments, the brain effects felt for the whole period from the time of consumption to several hours after the exposure had stopped.

In the fourth set of entanglement verification experiments, the test subject would take one-half of the 400ml fresh tap water exposed to microwave for 2min or magnetic pulses for 30min to his/her workplace located more than 50 miles away (in one case to Beijing located more than 6,500 miles away) and consumed the same at the workplace at a specified time. After 30min

from the time of consumption, the other half was exposed to magnetic pulses or laser light for 30min at the original location using the setup shown in Figure 2 and Figure 4 respectively. The test subject reported the brain effects felt without being told the content in the small container or details of the experiments for the whole period from the time of consumption to several hours after the exposure had stopped.

In the control studies for the first set of experiments, all test subjects did not feel anything unusual from the exposure to magnetic pulses except vague or weak local sensation near the site of exposure. In contrast, all general anesthetics studied produced clear and completely reproducible brain effects in various degrees and durations as if the test subjects had actually inhaled the same. These brain effects were first localized near the site of treatment and then spread over the whole brain and faded away within several hours. But residual brain effects (hangover) lingered on for more than 12 hours in most cases. Among the general anesthetics studied, chloroform and deuterated chloroform (chloroform D) produced the most pronounced and potent brain effects in strength and duration followed by isoflorance and diethyl ether.

While the test subjects did not feel anything unusual from consuming the tab water treated in the control experiments with magnetic pulses or laser light, all the general anesthetics studied produced clear and completely reproducible brain effects in various degrees and durations respectively similar to the observations in the first set of experiments. These effects were over the whole brain, intensified within the first half hour after the test subjects consumed the treated water and then faded away within the next a few hours. But residual brain effects lingered on for more than 12 hours as in the first set of experiments. Among the general anesthetics studied, again chloroform and deuterated chloroform produced the most pronounced and potent effect in strength and duration followed by isoflorance and diethyl ether.

Comparative experiments were also conducted on the authors themselves with chloroform and diethyl ether by asking them to inhale the vapors of chloroform and diethyl respectively for 5sec and compare the brain effect felt with those in the two sets of experiments described above. The brain effects induced in these comparative experiments were qualitatively similar to those produced in various experiments described above when chloroform and diethyl ether were respectively used for the exposure to photons of various sources.

With respect to the entanglement verification experiments, clear and consistently reproducible brain effects were experienced by the test subjects above and beyond what were noticeable in the control portions of the experiments under blind settings. With respect to the second, third and fourth sets of entanglement verification experiments, the only possible explanation for the brain effects experienced by the test subjects are that they were the consequences of quantum entanglement because the water consumed by the test subjects was never directly exposed to the magnetic pulses or the laser lights in the presence of the chemical substances.

More specifically, in the first set of entanglement verification experiments, the brain effects experienced by the test subjects were the same as those in which the setup shown in Figure 3 was used. In the second, third and fourth sets of these experiments, all test subjects did not feel anything unusual in the first half hour after consuming the first half of the water either exposed

to microwave/magnetic pulses or just sit on the shelf for more than 3 months. But within minutes after the second half of the same water was exposed to the laser light or magnetic pulses in the presence of general anesthetics, the test subjects would experience clear and completely reproducible brain effect of various intensities as if they have actually inhaled the general anesthetic used in the exposure of the second half of the water. The said brain effects were over the whole brain, first intensified within minutes after the exposure began and persisted for the duration of the said exposure and for the next several hours after the exposure had stopped. Further, all other conditions being the same, magnetic coil produced more intense brain effects than the red laser. Furthermore, all other conditions being the same, the water exposed to microwave or magnetic pulses before consumption produced more intense brain effects than water just sitting on the shelve for more than 3 months before consumption.

There are other indications that quantum entanglement was the cause of the brain effects experienced by the test subjects. For example, the said inducing mean did not depend on the wavelengths of the photons generated. Thus, mere interactions among the photons, a chemical substance and water will induce brain effects after a test subject consumes the water so interacted.

In light of the results from the entanglement verification experiments, we conclude that the brain effects experienced by the test subjects were the consequences of quantum entanglement between quantum entities inside the brains and those of the chemical substances under study induced by the entangling photons of the magnetic pulses or applied lights. More specifically, the results obtained in the first set of experiments can be interpreted as the consequence of quantum entanglement between the quantum entities in the brain and those in the chemical substances induced by the photons of the magnetic pulses. Similarly, the results obtained from the second sets of experiments can be explained as quantum entanglement between the quantum entities in the chemical substance and those in the water induced by the photons of the magnetic pulses, laser light, microwave or flashlight and the subsequent physical transport of the water entangled with the said chemical substance to the brain after consumption by the test subject which, in turn, produced the observed brain effects through the entanglement of the quantum entities inside the brain with those in the consumed water.

We would like to point out that although the indicators used to measure the brain effects were qualitative and subjective, they reflect the first-person experiences of the qualities, intensities and durations of these effects by the test subjects since their brains were directly used as experimental probes. Further, these effects are completely reproducible under blind experimental settings so that possible placebo effects were excluded. However, as with many other important new results, replications by others are the key to independently confirm our results reported here. Our experiments may appear simple and even “primitive” but the results and implications are profound.

We first chose general anesthetics in our experiments because they are among the most powerful brain-influencing substances. Our expectation was that, if nuclear and/or electronic spins inside the brain are involved in brain functions such as perception as recently hypothesized by us (Hu & Wu, 2002), the brain may be able to sense the effect of an external anesthetic sample through

quantum entanglement between these spins inside the brain and those of the said anesthetic sample induced by the photons of the magnetic pulses by first interacting with the nuclear and/or electronic spins inside the said anesthetic sample, thus carrying quantum information about the anesthetic molecules, and then interacting with the nuclear and/or electronic spins inside the brain.

We suggest here that the said quantum entities inside the brains are likely nuclear and/or electronic spins for the reasons discussed below. Neural membranes and proteins contain vast numbers of nuclear spins such as ^{1}H, ^{13}C, ^{31}P and ^{15}N. These nuclear spins and unpaired electronic spins are the natural targets of interaction with the photons of the magnetic pulses or other sources. These spins form complex intra- and inter-molecular networks through various intra-molecular J- and dipolar couplings and both short- and long-range intermolecular dipolar couplings. Further, nuclear spins have relatively long relaxation times after excitations (Gershenfeld & Chuang, 1997). Thus, when a nematic liquid crystal is irradiated with multi-frequency pulse magnetic fields, its ^{1}H spins can form long-lived intra-molecular quantum coherence with entanglement for information storage (Khitrin *et al*, 2002). Long-lived (~ .05 ms) entanglement of two macroscopic electron spin ensembles in room temperature has also been achieved (Julsgaard *et al.*, 2001). Furthermore, spin is a fundamental quantum process with intrinsic connection to the structure of space-time (Dirac, 1928) and was shown to be responsible for the quantum effects in both Hestenes and Bohmian quantum mechanics (Hestenes, 1983; Salesi & Recami, 1998). Thus, we have recently suggested that these spins could be involved in brain functions at a more fundamental level (Hu & Wu, 2002).

Several important conclusions and implications can be drawn from our findings. First, biologically/chemically meaningful information can be transmitted through quantum entanglement from one place to another by photons and possibly other quantum objects such as electrons, atoms and even molecules. Second, both classical and quantum information can be transmitted between locations of arbitrary distances through quantum entanglement alone. Third, instantaneous signaling is physically real which implies that Einstein's theory of relativity is in real (not just superficial) conflict with quantum theory. Fourth, brain processes such as perception and other biological processes likely involve quantum information and nuclear and/or electronic spins may play important roles in these processes.

Further, our findings provide important new insights into the essence and implications of the mysterious quantum entanglement and clues for solving the long-standing measurement problem in quantum theory including the roles of the observer and/or consciousness. Very importantly, our findings also provide a unified scientific framework for explaining many paranormal and/or anomalous effects such as telepathy, telekinesis and homeopathy, if they do indeed exist, thus transforming these paranormal and/or anomalous effects into the domains of conventional sciences.

In the context of mind-brain interaction, our above findings imply that the mind, if it is or behave like a quantum entity as in our spin-mediated consciousness theory, may affect the brain through quantum- entanglement mediated non-local processes in defiance of the second law of thermo-

dynamics. Though the details of such interaction still needed to be worked out in future studies, we here give a hypothetical example of how it might be like.

(b) Non-local Effect in Simple Physical Systems

Many if not most scientists do not believe that quantum effects or quantum information plays any role in consciousness (see, e.g., Tegmark, 2000). Thus, to gain credibility and make real progress any serious attempt at a quantum brain theory should start with a theoretically plausible hypothesis and then move to experimental work. Scientific methods dictate that a hypothesis should only achieve legitimacy if it is experimentally verified. Scientific methods also require that one conform one's knowledge of nature to repeatable observations. Thus, it is unscientific to reject what's observed repeatedly and consistently.

In the experiments summarized herein, we measured the changes of physical and/or chemical parameters in simple quantum-entangled systems. We found that the pH value and temperature of water in a detecting reservoir quantum-entangled with water in a remote reservoir can change against local environment when the latter is manipulated under the condition that the water in the detecting reservoir is able to exchange energy with its local environment (id). We also found that the gravity of water in a detecting reservoir quantum-entangled with water in a remote reservoir can change against local gravity when the latter was remotely manipulated (Hu & Wu, 2006d & 2007a).

The physical/chemical observables measured in the experiments were pH value, temperature and gravity measured with high-precision instruments. The successes of the experiments described herein were achieved with the aids of high-precision analytical instruments. Quantum-entangled stock water in individual volumes of 500*ml* or similar quantities was prepared as described previously (Hu & Wu, 2006b&c) which might then be split into smaller volumes or combined into larger ones based on needs.

The key experimental setup included (1) the analytical balance calibrated internally and stabilized in the underground room for more than one week before use and a tightly closed plastic first-reservoir containing 175*ml* water split from the 500*ml* stock water which is placed on the wind-shielded pan of the balance with 1-inch white foam in between as insulation; (2) the digital thermometer and calibrated pH meter placed into the middle of a glass second-reservoir containing 75*ml* water split from the 500*ml* stock water which is closed to prevent air exchange; and (3) the 25-litre Dewar containing 15-25 litres of liquid nitrogen which is located at a distant of 50 feet from the underground room and a tightly closed plastic third-reservoir containing 250*ml* water split from the 500*ml* stock water to be submerged into the liquid nitrogen in the Dewar at a specified time.

Experiments with this key setup were carried out as follows: (1) prepare the 500*ml* quantum-entangled stock water, divide the same into 175*ml*, 75*ml* and 250*ml* portions and put them into their respective reservoirs described above; (2) set up the experiment and let the instruments to stabilize for 30*min* before any measurements is taken; (3) record for 20*min* minute-by-minute changes of pH value and temperature of the water in the first-reservoir and weight of the second-reservoir with water before submerging the third reservoir into liquid

nitrogen; (4) submerge the third-reservoir with water into liquid nitrogen for 15*min* or another desired length of time and record the instrument readings as before; and (5) take the third-reservoir out of liquid nitrogen, thaw the same in warm water for 30*min* or longer and, at the same time, record the instrument readings as before. Control experiments were carried out in same steps with nothing done to the water in the third-reservoir.

In one variation of the above setup, the closed plastic third-reservoir was replaced with a metal container and instead of freeze-thaw treatment the water in the metal container was quickly heated to boiling within 4-5 minutes and then cooled in cold water. In a second variation of the above setup, the gravity portion of the experiment was eliminated and the water in the first and second reservoirs was combined into a closed thermal flask which prevents heat exchange between the water being measured and its local environment. In a third variation of the above setup, the gravity portion of the experiment was eliminated and the water in the first and second reservoirs was combined into a fourth plastic container in which 5ml concentrated HCl (38% by weight) was first added, then 20*g* NaOH powder was added and next the same water was transferred to a metal container and heated to boiling on a stove. In a fourth variation of the above first-setup, the 25-litre Dewar containing liquid nitrogen was replaced by a large water tank located 20-feet above the underground room which contained 200-gallon tap water sitting in room temperature for months and, instead of submersion, the water in the third-reservoir was poured into the large water tank the purpose of which was to quantum-entangle the poured water with the water in the large tank. In a fifth variation of the above setup, the gravity portion of the experiment was eliminated and the water in the first and second reservoirs was combined into a closed glass fourth-reservoir which was moved to a location more than 50 miles away from the Dewar for temperature measurement.

The measured pH value of the water in the second-reservoir changed during the three stages of manipulations of the water in the remote third-reservoir as follows. Within minutes after the remote third-reservoir was submerged into liquid nitrogen, during which the temperature of water being manipulated would drop from about 25ºC to -193 ºC, the pH value of the water in the second reservoir steadily stopped dropping and then started rising, but about 20*min* after the frozen water was taken out of liquid nitrogen and thawed in warm water the pH value of the same steadily leveled off and started dropping again. In contrast, the control experiments did not show such dynamics. It is known that the pH value of water increases as its temperature goes down to 0ºC. Therefore, the pH value of water being measured goes in the same direction as the remote water when the latter is manipulated. The difference in pH values from control in which no freeze-thaw was done at the point of thawing is about 0.010. However, if the water being measured is kept in a thermal flask to prevent heat exchange with the local environment, no effect on pH value was observed under freeze-thaw treatment of the remote water. Statistical analysis performed on data collected after freezing for 10*min* show that the results are significantly different under these different treatments/settings.

The measured temperature of the water in the second-reservoir changed during the three stages of manipulations of the water in the remote third-reservoir as follows. Before the submersion of the remote third-reservoir into liquid nitrogen the temperature of the water in the second-reservoir rose in small increments due to, by design, the slight temperature difference

between the local environment and the water inside the second reservoir; but within about 4-5 minutes after the remote third-reservoir was submerged into liquid nitrogen, during which the temperature of water being manipulated would drop from about 25ºC to -193 ºC, the temperature of the water in the second reservoir first stopped rising and then steadily dropped in small increments; and then within about 4-5 minutes after the frozen water was taken out of liquid nitrogen and thawed in warm water the temperature of the same first stopped dropping and then steadily rose again in small increments. In contrast, the control experiments did not show such dynamics. The temperature difference from control in which no freeze-thaw was done at the point of thawing is about 0.05^{o}C. However, if the water being measured is kept in a thermal flask to prevent heat exchange with the local environment, no dropping of temperature were observed under freeze-thaw treatment of the remote water. Statistical analysis performed on data collected after freezing for 10*min* show that the results are significantly different under these different treatments/settings.

The measured weight of the first-reservation changed during the three stages of manipulation of the water in the remote third-reservoir as follows. Before the submersion of the remote third-reservoir into liquid nitrogen the weight being measured drifted lower very slowly. But almost immediately after the remote third-reservoir was submerged into liquid nitrogen, during which the temperature and physical properties of water being manipulated drastically changed, the weight of the first-reservoir dropped at an increased rate, and after the frozen water was taken out the liquid nitrogen and thawed in warm water the weight of the same first stopped dropping and, in some cases, even rose before resuming drifting lower as further discussed below. In contrast, the control experiments did not show such dynamics. The weight difference from control in which no freeze-thaw was done at the point of thawing is about 2.5*mg*. Statistical analysis performed on data collected after freezing for 10*min* show that the results are significantly different under these different treatments/settings. In some cases, the weight of the water being measured not only stopped dropping for several minutes but also rose. The signatures of freezing induced weight decreases and thawing induced weight increases for three different thawing times are very clear.

With all experimental setups and their variations described herein, we have observed clear and reproducible non-local effects with the aids of high-precision analytical instruments and under well-controlled conditions. The physical observables used for measuring the non-local effects are simple ones which can be measured with high precisions. These effects are, even under the most stringent statistical analysis, significantly above and beyond what were noticeable in the control experiments.

We chose to use liquid nitrogen in a large Dewar placed at a distant location for manipulating water in our experiments because it can provide drastic changes in temperature and properties of water in a very short period of time. Our expectation was that, if the quantum entities inside the water being measured are able to sense the changes experienced by the quantum entities in the water being manipulated through quantum entanglement and further utilize the information associated with the said changes, the chemical, thermal and gravitational properties of the water might be affected through quantum entanglement mediated non-local processes (Hu & Wu, 2006a, b & c). The most logical explanation for these observed non-local effects is that they are

the consequences of non-local processes mediated by quantum entanglement between quantum entities in the water being measured and the remote water being manipulated as more specifically illustrated below.

First, when pH value of the water in the manipulation reservoir is high or low or is changing under direct manipulation such as extreme cooling or heating or addition of acidic or alkaline chemical, the measured pH in the detecting reservoir shifts in the same direction under the non-local influence of the water in the manipulation reservoir mediated through quantum entanglement and, under the condition that the detecting reserve is able to exchange energy with its local environment, as if H^+ in the latter is directly available to water in the detecting reservoir.

Second, when the temperature in the manipulation reservoir is extremely low or high or is changing under direct manipulation such as extreme cooling or heating or addition of heat-generating and/or property-changing chemical such as concentrated HCl or NaOH powder, the temperature in the detecting reservoir changes in the same direction under non-local influence of the water in the manipulation reservoir mediated through quantum entanglement and, under the condition that the detecting reserve is able to exchange heat with its local environment so that the local thermodynamic energy is conserved, as if the heat or lack of it in manipulation reservoir is directly available to the water in the detecting reservoir.

Third, when water in manipulation reservoir is manipulated though extreme cooling, heating or mixing with large quantum-entangled mass, *e.g.*, water, such that the quantum entanglement of the water under manipulation with its local environment changes, the weight of the water in the detecting reservoir also changes under the non-local influence of the manipulation reservoir mediated through quantum entanglement so that, it is hereby predicted, that the gravitational energy/potential is globally conserved.

We again suggest here that the said quantum entities inside water are likely nuclear spins for the reasons discussed above in Section 6 (a).

What we have done are the following: (1) We have found that the pH value of water in a detecting reservoir quantum-entangled with water in a remote reservoir changes in the same direction as that in the remote water when the latter is manipulated under the condition that the water in the detecting reservoir is able to exchange energy with its local environment; (2) We have also found that the temperature of water in a detecting reservoir quantum-entangled with water in a remote reservoir can change against the temperature of its local environment when the latter is manipulated under the condition that the water in the detecting reservoir is able to exchange energy with its local environment; (3) We have further found that the gravity of water in a detecting reservoir quantum-entangled with water in a remote reservoir can change against the gravity of its local environment when the latter was remotely manipulated such that, it is hereby predicted, the gravitational energy/potential is globally conserved; and (4) Thus, among other things we have realized non-local signaling using three different physical observables - pH value, temperature and gravity. However, as with many other experimental findings, independent replications are the key to verify our results. Therefore, we urge all interested scientists and the like to do their own experiments to verify and extend our findings.

Perhaps the most shocking is our experimental demonstration of Newton's instantaneous gravity and Mach's instantaneous connection conjecture and the relationship between gravity and quantum entanglement. Our findings also imply that the properties of all matters can be affected non-locally through quantum entanglement mediated processes. Second, the second law of thermodynamics may not hold when two quantum-entangled systems together with their respective local environments are considered as two isolated systems and one of them is manipulated. Third, gravity has a non-local aspect associated with quantum entanglement thus can be non-locally manipulated through quantum entanglement mediated processes. On a more fundamental level, our findings shed new lights on the nature and characteristics of quantum entanglement and gravity, reveal the true conflict between quantum theory and Einstein's theories of relativity, provide vital clues for resolution of the measurement problem in quantum mechanics, and support non-local hidden variable based theories such as Bohmian mechanics and a non-local cosmology.

Finally, our experimental findings show that macroscopic quantum effects such as quantum non-locality are robust in liquids such as water and maybe even in gases and solids at room temperature, thus support the proposition that quantum effects play important roles in biological systems including the functions of brain and consciousness. Our results also suggest that in quantum-entangled systems such as biological systems, quantum information may drive such systems to more ordered states against the disorderly effect of environmental heat.

7. Summary of Experimental Supports

Spin-mediated consciousness theory is supported by and, in the meantime, can explain all the existing experimental results obtained in the following areas of research:

1. Parapsychology: e.g., Rupert Sheldrake (see 2009), Dean Radin (see 2006).

2. Homeopathy (water memory): e.g., Jacques Benveniste (see Davenas et. al, 1988).

3. Remote effect of Human Intention: e.g., Robert Jahn & Brenna Dunne (see 2009), William Tiller (see 2007), Masaru Emoto? (see 2005), Uri Geller? (see 1999), various Qigong effects.

4. Non-local corrections of EEG: e.g., J. Grinberg-Zylberbaum (1987), Jiri Wackermann (see, 2004).

5. Sensed presence and altered state of consciousness under magnetic stimulations: Persinger e.t. al. (see, 1993, 2010a).

5. Non-local corrections of MRI signals: e.g., Jeanne Achterberg (2005).

6. Non-local correlations of EEG under magnetic stimulations: Michael Persinger, et. al. (2003, 2010b).

7. Non-local pattern in cognitive functions: e.g., Diederik Aerts et. al. (see 2000), Elio Conte et. al. (2003, 2010).

8. Light/environment-induced biological effects: e.g., Peter Gariaev (see, 1991), Bevan Reid (1989).

9. Consciousness collapse wave function: e.g., Dick J. Bierman (2003), also see Mark Germine? (1998).

10. Non-local effects of chemical substances on the Brain: Huping Hu & Maoxin Wu (2006a-c).

11. Non-local chemical, thermal and gravitational effects: Huping Hu & Maoxin Wu (2006d, 2007a-b).

12. Optical illusions: Efstratios Manousakis? (2007), Elio Conte et. al.(2009).

In this paper, we have summarized experimental support to spin-mediated consciousness theory from various sources including the results of our own. In doing so, we have also provided explanations based on this theory to experimental phenomena such as out-of-body experience and sensed presence, quantum-like cognitive functions and optical illusions. Whether one agrees or not with the spin-mediated consciousness theory is left for one alone to judge. In any event, the importance of the experimental results mentioned in this paper is obvious: quantum effects play important roles in brain/cognitive functions despite of the denials and suspicions of the naysayer and skeptics.

Appendix: Theoretical Consideration

Our current view is that Consciousness is both transcendent and immanent, that is, the transcendental aspect of Consciousness produces and influences reality through self-referential spin as the interactive output of Consciousness and, in turn, reality produces and influences immanent aspect of Consciousness as the interactive input to Consciousness also through self-referential spin (Hu, 2008b & 2009). Indeed, our experimental results on quantum entanglement of the brain with external substances suggest that Consciousness is not located in the brain but associated with prespacetime (Hu & Wu, 2006a-c). These results support the proposition that the transcendental aspect of Consciousness is the basis of reality.

What is human consciousness, then? It is our view that human consciousness is a limited or individualized version of the above dual-aspect Consciousness such that we have limited free will and limited observation/experience which is mostly classical at macroscopic levels but quantum at microscopic levels (*Id.*). For example, as a limited transcendental consciousness, we have through free will the choice of what measurement to do in a quantum experiment but not the ability to control the result of measurement (at least not until we can harness the abilities of our consciousness). That is, the result appears to us as random. On the other hand, at the macroscopic level, we also have the choice through free will of what to do but the outcome,

depending on context, is sometimes certain and at other times uncertain. Further, as a limited immanent consciousness, we can only observe the measurement result in a quantum experiment that we conduct and experience the macroscopic environment surrounding us as the classical world (*Id.*).

We now turn our attention to the details of how human experience (as limited immanent consciousness) is produced through the brain and how human free-will (as limited transcendental Consciousness) may operate through the brain according the principle of existence (Hu & Wu, 2009, 2010).

As illustrated in Figure 2.1, there are two kinds of interactions between an object (entity) outside the brain (body) and the brain (body). The first and commonly known kind is the direct physical and/or chemical interactions such as sensory input through the eyes. The second and lesser-known but experimentally proven to be true kind is the instantaneous interactions through quantum entanglement. The entire world outside our brain (body) is associated with our brain (body) through quantum entanglement thus influencing and/or generating not only our feelings, emotions and dreams but also the physical, chemical and physiological states of our brain and body.

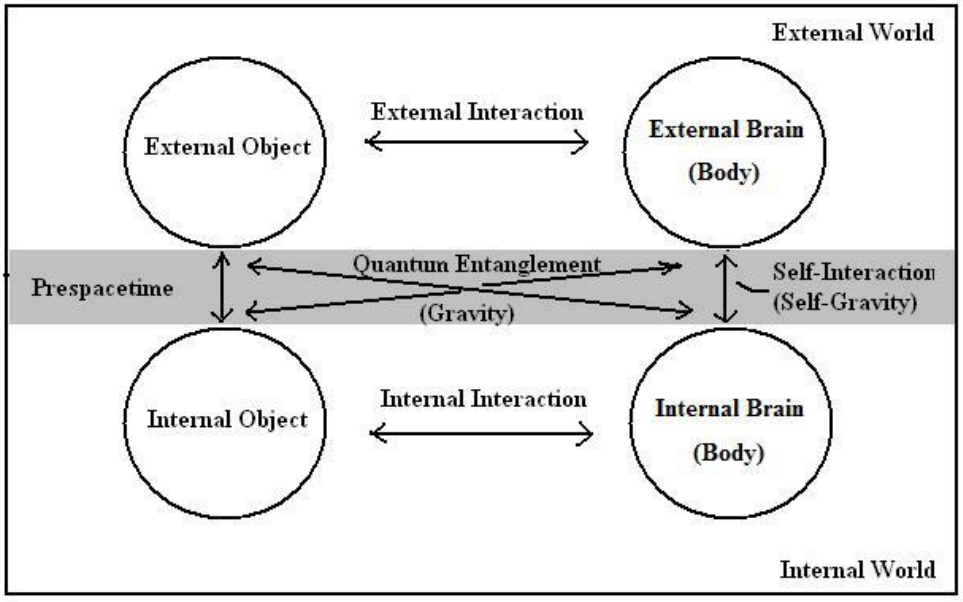

Figure 1. Interaction between an object and the brain (body) in the dual-world

Importantly, quantum entanglement may participate in (thus explain) visual experience and altered states of consciousness such as sensed presence and out-of-body experience which have been extensively studied experimentally by the Persinger's group in particular.

By way of an example (keep in mind that an interaction with the external world is accompanied by its counterpart interaction with the internal world): (1) A light ray reflected and/or emitted from an object outside the brain enters the eye, gets absorbed, converted and amplified in the

retina as propagating action potentials which travel to the central nervous system (CNS); (2) In the CNS, the action potentials drive and influence the mind pixels which according our theory is the nuclei such as protons with net nuclear spins and/or electrons with unpaired spins; and (3) Either the driven or influenced dynamic patterns of the mind-pixels in the internal world form the experience of the object, or more likely our visual experience of the object is the direct experience of the object in the external world through quantum entanglement established by the physical interactions. In the latter case, there is no image of the outside world in the brain. Further, in the case in which the object outside the brain is an image such as a photograph, there also exists the possibility that our visual experience is not only the experience of the photograph as such through quantum entanglement but also the experience of the object within the photograph through additional quantum entanglement. We hope that through careful experiments, we can find out which mechanism is actually true or whether both are true in reality.

The action potentials in the retina, the neural pathways and the CNS are driven by voltage-gated ion channels on neural membranes as embodied by the Hodgkin-Huxley model:

$$\partial_t V_m = -\frac{1}{C_m}\left(\sum_i (V_m - E_i) g_i\right) \qquad (1)$$

where V_m is the electric potential across the neural membranes, C_m is the capacitance of the membranes, g_i is the ith voltage-gated or constant-leak ion channel (also see, Hu & Wu, 2004c & 2004d). The overall effect of the action potentials and other surrounding factors, especially the magnetic dipoles carried by oxygen molecules due to their two unpaired electrons, is that inside the neural membranes and proteins, there exist varying strong electric field **E** and fluctuating magnetic field **B** that are also governed by the Maxwell equation:

$$\begin{pmatrix} E & -\boldsymbol{\sigma}\cdot\mathbf{p} \\ -\boldsymbol{\sigma}\cdot\mathbf{p} & E \end{pmatrix}\begin{pmatrix} \boldsymbol{\sigma}\cdot\mathbf{E} \\ i\boldsymbol{\sigma}\cdot\mathbf{B} \end{pmatrix} = 0 \quad \text{or} \quad \begin{pmatrix} \partial_t \mathbf{E} = \nabla\times\mathbf{B} \\ \partial_t \mathbf{B} = -\nabla\times\mathbf{E} \\ \nabla\cdot\mathbf{E} = 0 \\ \nabla\cdot\mathbf{B} = 0 \end{pmatrix} \qquad (2)$$

where we have set the classical (macroscopic) electric density and current $j^\mu = (\rho, \mathbf{j}) = 0$ inside the neural membranes. Further, for simplicity, we have not considered the medium effect of the membranes, that is, we have treated the membranes as a vacuum.

Microscopically, electromagnetic fields **E** and **B** or their electromagnetic potential representation $A^\mu = (\phi, \mathbf{A})$:

$$\begin{pmatrix} \mathbf{E} = -\nabla\phi - \partial_t \mathbf{A} \\ \mathbf{B} = \nabla\times\mathbf{A} \end{pmatrix} \qquad (3)$$

interact with proton of charge *e* and unpaired electron of charge –*e* respectively as the following Dirac-Maxwell systems:

$$\left(\begin{pmatrix} E-e\phi-m & -\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) \\ -\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) & E-e\phi+m \end{pmatrix}\begin{pmatrix} \psi_{e,-} \\ \psi_{i,+} \end{pmatrix} = L_M\psi = 0\right)_p \tag{4}$$

$$\begin{pmatrix} E & -\boldsymbol{\sigma}\cdot\mathbf{p} \\ -\boldsymbol{\sigma}\cdot\mathbf{p} & E \end{pmatrix}\begin{pmatrix} \boldsymbol{\sigma}\cdot\mathbf{E} \\ i\boldsymbol{\sigma}\cdot\mathbf{B} \end{pmatrix} = \begin{pmatrix} -i\boldsymbol{\sigma}\cdot(\psi^\dagger\beta\boldsymbol{\alpha}\psi) \\ -i(\psi^\dagger\beta\beta\psi) \end{pmatrix}_p \tag{5}$$

and

$$\left(\begin{pmatrix} E+e\phi-m & -\boldsymbol{\sigma}\cdot(\mathbf{p}+e\mathbf{A}) \\ -\boldsymbol{\sigma}\cdot(\mathbf{p}+e\mathbf{A}) & E+e\phi+m \end{pmatrix}\begin{pmatrix} \psi_{e,+} \\ \psi_{i,-} \end{pmatrix} = L_M\ \psi = 0\right)_e \tag{6}$$

$$\begin{pmatrix} E & -\boldsymbol{\sigma}\cdot\mathbf{p} \\ -\boldsymbol{\sigma}\cdot\mathbf{p} & E \end{pmatrix}\begin{pmatrix} \boldsymbol{\sigma}\cdot\mathbf{E} \\ i\boldsymbol{\sigma}\cdot\mathbf{B} \end{pmatrix} = \begin{pmatrix} -i\boldsymbol{\sigma}\cdot(\psi^\dagger\beta\boldsymbol{\alpha}\psi) \\ -i(\psi^\dagger\beta\beta\psi) \end{pmatrix}_e \tag{7}$$

where β and $\boldsymbol{\alpha}$ are Dirac matrices.

In equations (4) and (6), the interactions (couplings) of **E** and/or **B** with proton and/or electron spin operator $(\boldsymbol{\sigma})_p$ and $(\boldsymbol{\sigma})_e$ are hidden. But they are due to the self-referential Matrix Law which causes mixing of the external and internal wave functions and can be made explicit in the determinant view as follows. For Dirac form, we have:

$$\left(\begin{pmatrix} E-e\phi-m & -\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) \\ -\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) & E-e\phi+m \end{pmatrix}\begin{pmatrix} \psi_{e,-} \\ \psi_{i,+} \end{pmatrix} = L_M\psi = 0\right)_p \tag{8}$$

$$\rightarrow \left(\begin{pmatrix} (E-e\phi-m)(E-e\phi+m)- \\ \\ (-\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}))(-\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A})) \end{pmatrix} I_2\psi_{e,-}\psi^*_{i,+} = 0\right)_p$$

$$\rightarrow \left(\left((E-e\phi)^2 - m^2 - (\mathbf{p}-e\mathbf{A})^2 + e\boldsymbol{\sigma}\cdot\mathbf{B}\right)I_2\psi_{e,-}\psi^*_{i,+} = 0\right)_p$$

For Weyl (chiral) form, we have:

$$\left(\begin{pmatrix} E-e\phi-\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) & -m \\ -m & E-e\phi+\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}) \end{pmatrix}\begin{pmatrix} \psi_{e,r} \\ \psi_{i,l} \end{pmatrix} = 0\right)_p \tag{9}$$

$$\rightarrow \left(\left((E-e\phi-\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A}))(E-e\phi+\boldsymbol{\sigma}\cdot(\mathbf{p}-e\mathbf{A})) - m^2\right)I_2\psi_{e,r}\psi^*_{i,l} = 0\right)_p$$

$$\rightarrow \left(\left((E-e\phi)^2 - m^2 - (\mathbf{p}-e\mathbf{A})^2 + e\boldsymbol{\sigma}\cdot\mathbf{B}\text{-}ie\boldsymbol{\sigma}\cdot\mathbf{E}\right)I_2\psi_{e,r}\psi^*_{i,l} = 0\right)_p$$

These two couplings are also explicitly shown in Dirac-Hestenes formulism or during the process of non-relativistic approximation of the Dirac equation in the present of external electromagnetic potential A^μ. We can carry out the same procedures for an electron to show the explicit couplings of $(\boldsymbol{\sigma})_e$ with **E** and **B**.

One effect of the couplings is that the action potentials through **E** and **B** (or A^{μ}) input information into the mind-pixels in the brain (Hu & Wu, 2004c, 2004d & 2008a). Judging from the above Dirac-Maxwell systems, we are inclined to think that said information is likely carried in the temporal and spatial variations of **E** and **B** (frequencies and timing of neural electric spikes and their spatial distributions in the CNS). Another possible effect of the couplings is that they allow the transcendental aspect of consciousness through wave functions (the self fields) of the proton and/or electron to back-influence **E** and **B** (or A^{μ}) which in turn back-affect the action potentials through the Hodgkin-Huxley neural circuits in the CNS (also see, Hu & Wu, 2007d & 2008a).

We will carry out detailed studies of the above sketched possible mechanisms elsewhere. Here we will speculate a bit about how human free-will as a macroscopic quality of limited transcendental consciousness may originate microscopically under the particular high electric voltage environment inside the neural membranes. For example, one possibility is that the human free will as thought or imagination produces changes in the phase of external and internal wave functions:

$$e^{i0} = e^{-i(\Delta Et - \Delta \mathbf{p}\cdot\mathbf{x})+i(\Delta Et - \Delta \mathbf{p}\cdot\mathbf{x})} = \left(e^{-i(\Delta Et - \Delta \mathbf{p}\cdot\mathbf{x})}\right)_e \left(e^{+i(\Delta Et - \Delta \mathbf{p}\cdot\mathbf{x})}\right)_i \qquad (10)$$

where $(\ )_e$ and $(\ )_i$ respectively indicate external and internal wave functions, which in turn back-affect **E** and **B** (or A^{μ}) in the high electric voltage neural membranes through the Dirac Maxwell systems illustrated above.

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